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Subject: Dwarf Mistletoe and other Insect and Disease Activity in the Rim Lakes Forest Health Project Area

To: District Ranger, Black Mesa RD

At the request of Gayle Richardson, District Silviculturist, I evaluated the Rim Lakes Forest Health Project Area (RLFHP) for insect and disease activity. The primary objectives of the 33,000 acre RLFHP are to reduce forest fuels, decrease fire hazard, manage vegetation, and improve wildlife habitat. There is an emphasis to manage for goshawk habitat by applying uneven-aged silviculture treatments in ponderosa pine forest types. Since the incidence of dwarf mistletoe infection within a stand greatly influences the growth and development of trees overtime, the prevalence of dwarf mistletoe needs to be considered when selecting sites for even- or uneven-aged management. This report includes information on general existing stand conditions, particularly on dwarf mistletoe incidence and its influence on stand development, and makes recommendations to minimize impacts of dwarf mistletoe infection in developing stands. Other insects and pathogens are discussed.

Current Insect and Disease Activity

The majority of the RLFHP area consists of dense stands of ponderosa pine; higher elevations and north slopes are interspersed with Douglas-fir, aspen, and southwestern white pine; while lower elevations have pinyon and juniper. Approximately 800 acres of the area was burned in the 2002 Rodeo-Chediski Fire. Natural disturbances and historic processes have been altered for more than 100 years and much of the area is at increased risk of unnaturally intense wildland fire behavior and bark beetle outbreaks. The primary purpose of the project is to decrease hazardous forest fuels and reduce the risk of wildfire, while maintaining or improving forest health. Other benefits include protection and enhancement of recreation areas and wildlife habitat, and improvement of riparian, aspen and gambel oak habitat.

Figure 1 Southwestern dwarf mistletoe infection can stunt the growth of understory trees.

Dwarf mistletoe infection in ponderosa pine and Douglas-fir is common throughout the area (Figure 1). Based on stand exam data, southwestern dwarf mistletoe was observed in ponderosa pine on approximately 72% of sites. The incidence of dwarf mistletoe is quantified

during stand exams. Inventory trees are assigned dwarf mistletoe ratings (DMR) using Hawksworth's[i] 6-class system. This rating system divides the live crown of trees into thirds, and each third is rated separately as: 0, no mistletoe infection; 1, less than 50% of live branches infected; 2, more than 50% of live branches infected. The ratings for each third are totaled to obtain a DMR for a tree and a mean DMR for a site (stand) is calculated by adding the DMRs for all live trees, infected and uninfected, greater than 1 inch diameter at breast height (DBH) in the stand and dividing by the total number of trees. Approximately one-half of the infected sites are lightly infected (stand DMR <0.5), and the other half are moderately (stand DMR 0.5 to 1.0) or heavily (stand DMR >1.0) infected. There are several stands with DMR levels greater than 2.0, in which even the smallest diameter size classes are intensely infected.

The percentage of host trees infected with dwarf mistletoe was also calculated from stand exam data, since this information is useful in determining silvicultural prescriptions. Regional guidelines suggest if less than 25% of host trees are infected with dwarf mistletoe than uneven-aged treatments may be considered, but if more than 25% of host trees are infected even-aged treatments are recommended. In the RLFHP, 28% of forested sites are uninfected with southwestern dwarf mistletoe and 32% of the sites have less than 25% of ponderosa pine infected (i.e. trees >5" DBH). Approximately 40% of forested sites have greater than 25% southwestern dwarf mistletoe infected ponderosa pine.

Douglas-fir dwarf mistletoe is less common in Douglas-fir, which was observed in 35% of surveyed stands. Most sites are uninfected with Douglas-fir dwarf mistletoe (65%) or have less than 25% of the host infected (18%). Only 16% of forested sites have more than 25% of the Douglas-fir infected.

Bark beetle activity in ponderosa pine currently appears to be at endemic levels. An outbreak of bark beetles in 2002-2003 resulted in widespread mortality across Arizona, including mortality in the RLFHP area. The outbreak was primarily the result of several native bark beetle species responding to the weakened condition of moisture-stressed, over-crowded forests. Trees on stress-prone sites were most affected.

Bark beetle activity in Douglas-fir (Douglas-fir beetle) and white fir (fir engraver beetle) has been increasing over the past few years in the RLFHP area, especially in the canyons.

Browsing of hardwood and conifer regeneration by livestock and game ungulates is heavy throughout the RLFHP area. The only tree species unaffected by browse is southwestern white pine.

Figure 2 Aspen with trunks damaged by elk antler rubbing.

Aspen exists over approximately one-third of the assessment area in small isolated patches. These patches typically consist of a few overstory trees with a thin component of 3-8" DBH trees. Elk are particularly damaging to aspen, browsing on aspen suckers, rubbing antlers on mid-sized trees (Figure 2), and barking larger trees. Several aspen sites showed signs of decline marked by mortality and dieback of crowns, similar to what has been observed across Arizona over the past several years.

Treatment Options to Reduce Impact of Dwarf Mistletoe, Bark Beetles, and Elk

Dwarf Mistletoe

Dwarf mistletoes are parasitic, seed-bearing plants that depend on their hosts almost completely for water and nutrients. They cause significant changes in physiological processes and structural characteristics of infected trees, which result in changes in the structure and function of forest communities[ii] [iii]. Infected host trees experience growth loss, mortality, reduced seed production and viability, and a predisposition to bark beetles[iv] and root disease. Overall effects on forest structure in a site that has been infected for many generations include: increased stand openings; lower crown canopy; denser canopy due to witches' brooms; and fewer large diameter trees.

The direct and indirect effects of dwarf mistletoe infection on its host can provide forage and nesting habitat for many species of birds[v] and mammals[vi]. Although several bird species have been observed feeding on mistletoe berries and shoots, there is little quantitative data on any except for blue grouse, which has been found to consume Douglas-fir dwarf mistletoe shoots in the fall. Insectivorous birds feed on insects that feed on the mistletoe and on bark beetles that attack weakened infected trees. Recent research has measured positive, negative, and null correlations between mistletoe related variables (e.g., the amount of mistletoe on a site and snag density) and bird species abundance in ponderosa pine sites in northern Arizona[vii]. Of the 16 bird species investigated, a positive relationship was found for 4 species, negative correlation for 5 species, and no correlation for 7 species. Three of the 4 species that were positively correlated with dwarf mistletoe infestation or snag density were cavity-nesting birds. The only foliage nesting bird with a positive relationship was western tanager. Bennetts et al.[viii] found a positive correlation between mistletoe infection and 24 bird species; however, those Colorado study sites had a mixed-conifer and understory shrub component absent from the study sites in Arizona.

The focus of managing mistletoe is to reduce the impacts of mistletoe infection on forested sites. Mistletoe management is a continuous process, since new dwarf mistletoe infections take 3- to 5-years (latent period) to produce aerial shoots and not all infection can be detected and removed during one treatment. At least one treatment will be needed 5 to 10 years after an initial treatment, but can be accomplished during regularly scheduled silvicultural or prescribed fire treatments.

Several features of dwarf mistletoes make them ideal candidates for cultural management[ix]:

- Dwarf mistletoes require a living host to survive. Mistletoe dies when an infected tree or branch is cut.
- Dwarf mistletoes are commonly restricted to a single host species or a group of closely related species. Non-host species can be favored during stand treatments.
- Dwarf mistletoes have fairly long life cycles and slow spread rates.
- Spread rates average only 1 foot per year. Although birds contribute to long-distance dispersal of seeds, this is rare and of little practical significance from a control perspective.
- Southwestern dwarf mistletoe-infected ponderosa pine trees are generally easy to detect due to the presence of yellow-orange shoots and witches' brooms. Trees in heavily

infested stands show signs of short stature, decline, and mortality.

Managing dwarf mistletoe is difficult in stands under uneven-age management. Spread from overstory to understory trees, known as vertical spread, is rapid when seeds from infected overstory trees shower down onto younger trees. When newly infected trees in the understory begin to produce seed tree-to-tree, or lateral spread occurs among the young trees. Infection then progresses outward beyond the range of seeds produced from overstory trees. Researchers[x] [xi] have measured the distance of infected seedlings from the source of overstory trees at different time intervals. In 20-year-old trees, nearly all infection is found within 35 feet of infected overstory trees. In 50-year-old trees, lateral spread of dwarf mistletoe increased the rate to nearly 80 feet in open stands and 65 feet in dense stands.

If uneven-aged treatments are to be applied in dwarf mistletoe infected stands, such as when implementing goshawk guidelines, it is best to select lightly infected stands on high quality sites. Although the presence of dwarf mistletoe in a stand is typically not related to site quality, the abundance and impacts of the pathogen on the growth and mortality of the host are strongly related to the quality of a site, soil type, and slope[xii]. The incidence of southwestern dwarf mistletoe can be higher on dry sites with gentle slopes.

The University of Montana in conjunction with the Bureau of Indian Affairs developed the following guidelines in managing ponderosa pine stands infected with southwestern dwarf mistletoe:

Condition	**Recommended Treatment Options**
Less than 15% of stems infected	Individual Tree Selection
15%-25% stems infected	Group selection, less than 2 acres
Greater than 25% stems infected	Even-aged treatment

The relationship between percent infected and average stand dwarf mistletoe ratings needs to be explored before the latter can be used to drive management guidelines.

In certain stands with low-level, patchy distributions of dwarf mistletoe infection, group selection can be used to decrease disease incidence and impacts. However, residual trees located on the edges of openings need to be mistletoe-free in order to allow disease-free regeneration to develop in the newly created openings. Since latent infections are likely along the edges of a mistletoe center, it is recommended to cut 30-40 feet beyond the edge of visible infection. Limitations on size of openings, and reserve tree requirements can hinder the success of group selection treatments in dwarf mistletoe infected stands. Followup surveys and treatments need to be conducted 5-10 years after group removals in order to check the perimeter for infected trees.

Prescribed burns can also be used to reduce dwarf mistletoe infection levels. Heavily infected trees have been shown to have reduced post-burn survival rates compared to lightly infected or non-infected trees[xiii] [xiv]. Limbs located in the lower crowns of trees are killed during fire. Since dwarf mistletoe infections are generally more abundant in the lower crowns of infected trees, infection levels are decreased by the death of lower limbs.

Bark Beetles

No stand hazard rating models have been developed for pine engraver beetles attacking ponderosa pine, primarily because beetle populations are driven by drought and factors leading to the creation of large amounts of slash. However, recent work, to be published this year, suggests that lower elevation sites with higher densities are more prone to ips activity. Stand hazard rating for Dendroctonus bark beetles of ponderosa pine involves measures of tree size, stand or group density (basal area), and the percent of host trees within the stand. In general, ponderosa pine stands that have an average DBH greater than 12 inches and a basal greater than 120 ft2/acre are considered at high risk to bark beetle attack[xv] [xvi] [xvii]. Stands that have less than 80 square feet of basal area per acre are considered the lowest risk. In order to protect residual trees from attack from ips beetles all fresh cut "slash" (cut tree trunks, limbs, and trimming debris) should be created and treated properly to keep beetles from breeding in it and moving into adjacent residual green trees[xviii].

Elk

Browsing of aspen regeneration from large ungulates, particularly elk has been a major concern for decades across Arizona[xix]. Since the mid-1980s, forest managers have built 6½ ft tall fences around aspen regeneration to prevent elk browsing. These fences are expensive to install and maintain. Although originally intended as a temporary measure until the trees obtained sufficient height to escape browse, it was soon realized that fences need to remain for a longer period[xx] [xxi]. Elk damage aspen in three ways: they browse new shoots, rub saplings with antlers and gnaw or bark trees for phloem. The browsing of shoots is so prolific that it is rare to see these ramets survive more than a couple of years, and that only happens when the mature tree is still living. Barking and rubbing has been positively correlated to damage by secondary pathogenic fungi causing stem cankers and decay[xxii] that play a role in the death of trees. Stem decay fungi contribute to stem instability as the trees grow. Permanent exclusion fences are required to allow for successful reproduction following silvicultural treatments or fire.

Recommendations

Dwarf mistletoes markedly affect the growth, form, and survival of infected trees. Treatments to mitigate mistletoe impacts can be integrated with other treatment activities like reducing a stands susceptibility to fire or insect outbreaks. Uneven-aged treatments should only be considered in non-dwarf mistletoe infected stands or lightly infected stands on good quality sites that have well defined infection patches in which group selection can be used to target the removal of infected trees. Increasing space between trees helps limit spread because seeds of dwarf mistletoe are explosively released and typically travel 10 to 40 feet from a fruit bearing plant. This reduces infection levels while still allowing trees to grow to maturity.

Even-aged treatments are recommended in moderately to heavily dwarf mistletoe infected stands. Group selection can be used in moderately infected stands that are adequately stocked can be thinned by targeting the more severely infected trees while also emphasizing the most vigorously growing trees. Heavily infected stands should either receive a regeneration treatment, such as a shelterwood, or be deferred from treatment.

Regardless of the emphasis on even-aged or uneven-aged stands, proper selection and marking of leave trees is paramount to the success of treatment. In stands selected for group selection treatments it is important to attempt to remove trees with latent infections, as described above,

cutting 30-40 feet beyond the edge of visible infection. In stands receiving individual tree selection treatments, leave trees should have none to very little mistletoe infection. Monitoring for followup treatments in 5 to 10 years is recommended.

There is a potential for more white fir and Douglas-fir beetle caused mortality. Based on studies in the Rocky Mountains, Douglas-fir beetles preferentially attack large, old trees in dense stands with a high Douglas-fir component[xxiii]. Active stand management (thinning) provides the best long term prevention for minimizing damage by Douglas-fir beetle[xxiv], and a fuels reduction project should help to lower stand risk. However, log decks, thinning slash, and subsequent burning may pose a short-term risk to residual trees in the thinning unit or surrounding areas. Timing of thinning treatments, chipping, and placement of potential brood material in open areas should help to minimize potential impacts. There are also chemical options for area protection should a need arise.

Douglas-fir beetle caused mortality. Based on studies in the Rocky Mountains, Douglas-fir beetles preferentially attack large, old trees in dense stands with a high Douglas-fir component[xxv]. Active stand management (thinning) provides the best long term prevention for minimizing damage by Douglas-fir beetle[xxvi], and a fuels reduction project should help to lower stand risk. However, log decks, thinning slash, and subsequent burning may pose a short-term risk to residual trees in the thinning unit or surrounding areas. Timing of thinning treatments, chipping, and placement of potential brood material in open areas should help to minimize potential impacts.

Thinning slash may pose a short-term bark beetle risk to residual trees in the thinning units or surrounding areas depending on the timing of thinning, local population of pine engraver beetles, and site and environmental factors such as site quality and precipitation. Our office recommends that slash be generated between late summer and the end of December, if possible, in order to lessen the buildup of ips bark beetles. Slash piles should be placed in stand openings as much as possible and the largest diameter slash put on the outside of the pile to promote quick drying. Tepee style slash piles with branches and small-diameter slash in the middle and the larger diameter material on the outside.

Excessive browsing by ungulates, particularly elk, is limiting the successful regeneration of aspen, Gambell oak, and most conifer species across the assessment area. Monitoring and reductions in browse-pressure need to be explored.

If you have any questions, please give me a call at (928) 556-2075.

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